

HEAT PIPE COOLING FOR TURBINE STATORS

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BACKGROUND OF THE INVENTION

This invention deals generally with turbine engines and more specifically with the cooling of turbine engine stators.

It is generally acknowledged that the performance of turbine engines is limited by the requirements for cooling the engine components. Although increasing engine operating temperatures would improve engine performance, such temperature increases will adversely affect the materials used for engine components unless engine cooling is significantly improved.

One of the critical components requiring cooling is the turbine nozzle. In the present designs for high pressure turbine engines, cooling of the nozzle is typically accomplished by bleeding air from the compressor and directing the air through the nozzle components to be cooled. However, such a technique adversely affects the performance of the engine. The bleeding of compressor air increases fuel consumption, decreases shaft horsepower, reduces the efficiency, and decreases the power to weight ratio.

There have been some attempts to build heat pipes into turbine components, but these efforts have not been directed toward achieving the necessary cooling effects. U.S. Pat. Nos. 4,207,027 to Barry et al and 5,439,351 to Artt have disclosed turbine airfoils with internal heat pipes, however, the goals of those patents were merely to equalize the temperature throughout the air foil, and neither patent addressed disposing of the heat to which the components were subjected.

In order to improve the performance of a high temperature turbine it is imperative, not only to equalize the temperature on the components, but also to transfer the heat to locations from which it can be removed so that the components can be maintained at lower temperatures.

SUMMARY OF THE INVENTION

The present invention uses heat pipes within the stator of a turbine engine nozzle to transfer the heat from the stator to a remote location for disposal.

The invention is a heat pipe for cooling a turbine engine stator airfoil blade which has a multiple chamber heat pipe evaporator within the blade. The structure has an evaporator section located within each of three chambers. These evaporators, formed as leading edge, middle, and trailing edge chambers within the blade are separated by structural support ribs within the airfoil structure. The leading edge and middle section evaporator chambers inside the blade shaped airfoil are each constructed with a continuous fine pore metal powder wick covering the entire internal surface of the chamber. Each wick thereby surrounds its chamber's central vapor space.

However, the wick in the trailing edge of the blade can be formed somewhat differently. While three sides of the inside surface of the chamber are coated with metal powder wick, the narrowed portion at the very trailing edge can be filled with screen wick which is in capillary contact with the adjacent metal powder wick, but extends into the vapor space of the trailing edge chamber. This configuration pro-

vides a large pore path along which vapor generated at the very trailing edge of the chamber can more easily be vented to the chamber's vapor space.

In order to help assure that the temperatures within the three chambered evaporator are equalized, the wicks of the various chambers can be interconnected with each other. One method is to connect the wick of one chamber to the wick of another chamber by a capillary artery. It is also practical to join the wicks of two chambers with a connection wick by extending metal powder wick between two chambers by forming wick around or through openings in the support ribs within the turbine stator. Thus, liquid is easily transferred between two chambers because the same capillary artery is embedded in the metal powder wick in each of the chambers or the metal powder wicks of the chambers are actually continuous. Such capillary connections are relatively short because they only pass through or around the support ribs between the chambers.

The leading edge chamber and middle chamber of the evaporator also each have capillary arteries which extend through the adiabatic section of the heat pipe and terminate in the heat pipe condenser wick in the heat sink structure which is located within and cooled by the stream of the input air to the combustor. For ease of construction, it is desirable to simply continue one of the capillary arteries which interconnect the condenser to the middle chamber into the trailing edge chamber so that it serves as the capillary connection between the wicks in the middle and trailing edge chambers.

The invention can therefore cool the turbine stator blades which are subjected to the extreme temperatures of the combustor output air, transferring the heat from the stators to the cooler combustor input air. Parenthetically, the heating of the combustor input air by the heat pipe condenser favorably affects the engine efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a portion of the structure of a high pressure turbine nozzle.

FIG. 2 is a cross section view of the heat pipe evaporator section of the turbine nozzle of FIG. 1 at location 2—2.

FIG. 3 is a cross section view of the heat pipe adiabatic section of the turbine nozzle of FIG. 1 at location 3—3.

FIG. 4 is a cross section view of the heat pipe condenser section of the turbine nozzle of FIG. 1 at location 4—4.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a perspective view of a portion of the typical structure of a high pressure turbine nozzle which includes the invention, a nozzle cooling heat pipe 10 within which evaporator section 12 is connected to condenser section 14 through adiabatic section 16. In normal operation of the turbine, engine stator vane 18 is located within stream A of the engine combustor hot outlet gas, and is therefore heated to extremely high temperatures. However, combustor inlet air B, which is much cooler than output gases A, is also available, and the present invention uses it to advantage.

Heat pipe 10 transfers heat from stator vane 18 to condenser fin 20, and thereby not only cools stator vane 18 but advantageously preheats input air B. It should be appreciated that stator vane 18 and condenser fin 20 are each just one of many such structures in the typical gas turbine nozzle. There are many more stator vanes attached to shroud band 22 and hub band 24, and they are all located to form a